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(54) LAMP FOR IRRADIATION OF TUMOURS

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(57) Claim

1. Apparatus for effecting useful irradiation of tumours having therein a photoactive drug, including an incandescent filament to provide a light source, a reflector surrounding the incandescent filament a characteristic of which reflector with respect to an outlet aperture within the apparatus is that light when emanating from the filament will be at least substantially directed and reflected to pass through the aperture so as not to have greater than a selected angle of diversion from an axis of a lamp, a chamber connected to the outlet aperture being otherwise shaped so that light passing therethrough from the filament will retain at least substantially its entry angle of divergence with respect to the axis of the lamp and containing therewithin a liquid effective to provide absorption of a range of wave lengths of light passing therethrough, and at an end of said chamber filters including an interference filter positioned and shaped and of such a size that light emanating from the said filament and having passed through the said liquid will strike said interference filter with an angle of incidence to the filter not greater than a selected suitable value.

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COMPLETE SPECIFICATION

(ORIGINAL)



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TO BE COMPLETED BY APPLICANT

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Complete Specification for the invention entitled:

"AN IMPROVED LAMP"

LODGED AT SUB-OFFICE
29 AUG 1983
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The following statement is a full description of this invention, including the best method of performing it known to ~~me~~ us.

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This invention relates to an improved lamp especially intended for use for irradiation of malignant tumours where these have had incorporated in them a receptive photoactive drug.

It is known for instance that "HAEMATOPORPHYRIN DERIVATIVE" when injected into the human body or into other living animals can have the effect of selectively making tumours more susceptible to destruction when irradiated with a selected radiation than healthy tissue.

There are considerable difficulties surrounding the use of this technique.

It is desirable to have a very high intensity of irradiation onto the affected tissue but it can be a significant problem that if the radiation is too intense especially with the healthy tissue, significant tissue damage can result.

It is known to propose a laser for use in this application in that certain laser beams can be generated in a very narrow bandwidth.

The problem however with lasers is that it is very difficult to obtain a high power of transmission and the result of this to get sufficient radiation in respect of the tissue is that the irradiation must take a substantial period of time.

Considering some applications such as the case where the patient has been subject to surgery with the vulnerable areas open, it is preferable that the patient should not

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be unduly kept under anesthetic or in an exposed situation and therefore the time needed for irradiation should be as short as possible.

After considerable investigation we have found that a useful irradiation can be achieved by using an incandescent light source.

Perhaps more importantly, by using an incandescent light source, a sufficient output within the necessarily restricted range of wave lengths can be achieved to significantly lessen the time of irradiation needed as compared to previous means available.

Furthermore, it has been found that by careful selection of design criteria, an incandescent lamp for this purpose can be achieved which has small outer dimensions so that the lamp can be substantially rugged and portable, and both economic and useful in a variety of applications.

According to this invention there is proposed a lamp which can be useful for irradiation of tumours having therein a photoactive drug which includes an incandescent filament to provide a light source, a reflector surrounding the incandescent filament a characteristic of which reflector with respect to an outlet aperture within the apparatus is that light when emanating from the filament will be at least substantially directed and reflected to pass through the aperture so as not to have greater than a selected angle of divergence from an axis of a lamp, a chamber connected to the outlet aperture and having sides and being otherwise shaped so that light passing therethrough from the filament will retain at least substantially its entry angle of divergence with respect

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to the axis of the lamp and containing therewithin a liquid effective to provide absorption of a range of wave lengths of light passing therethrough, and at an end of said chamber, filters including an interference filter positioned and shaped and of such a size that light resulting from the said filament and having passed through the said liquid will strike said interference filter with an angle of incidence to the filter not greater than a selected suitable value.

Preferably a reflector is located so as to accept light passing through the several filters and so reflect this so as to concentrate the light through a smaller outlet there being as a consequence a larger range of angles of divergence through which the light will be distributed.

Preferably, the maximum angle of divergence which is selected for the light emanating from the aperture of the reflector surrounding the filament is approximately 30 degrees.

Preferably the liquid within the chamber providing for selective light absorption is water and in a preferable arrangement, the water which will absorb light in the infrared range of wave lengths is also used to cool the reflector and is recirculated.

Preferably, the filament providing for the incandescent light output is substantially coiled into a cylindrical shape and is coaxial with the axis of the reflector and the lamp.

It has been discovered that by providing a compound paraboloidal reflector associated with a filament positioned as described, that this provides an effective reflector

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which can occupy a reasonably small space and which can nonetheless provide light available from the filament emanating from an exit aperture within a selected limited angle of divergence from the axis of the lamp.

To assist in an understanding of the invention, this will be described with respect to a particular apparatus which shall be described with the assistance of drawings attached hereto.

In Fig. 1 of the attached drawings this shows in cross-section the preferred embodiment and Fig. 2 is a schematic diagram of the end concentrator and Fig. 3 is a schematic diagram showing the specific required relationships between the surface of the reflector, the exit aperture, the angle of maximum divergence from the axis of the lamp and the filament as used in the preferred embodiment.

Referring in the first instance to Fig. 3, there is a filament that can be assumed to be of cylindrical shape of radius (r_F) length (1) aligned along an axis (OX) and having a front edge at (FF').

The exit aperture of the reflector is defined by (AA') and the portion (A) to (B) of the cross-section has a shape which is parabolic having a focus at (F') and axis parallel to (FA') making an angle ω_o equal to the maximum angle of divergence from the axis of the lamp. The portion (B) to (C) is a parabola having a focus at (F) and axis (FA').

The portion (C) to (D) is of circular shape having a centre at (F).

The location (C) is a linear extension of the line (A') to (F). The dimension (DD') is determined by the diameter of the bulb (2 of Fig. 1)

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The reflector has a central axis (OX) and is a surface of revolution accordingly.

Selection of an appropriate filament and having this located in relation to a selected outlet aperture of selected radius (r) determines with the maximum angle of divergence from the axis of the lamp the shape and size of the parabolic shape of the portion of (A) to (B) and likewise the shape of the parabolic portion (B) to (C) and the radius of the portion (C) to (D).

For given filament dimensions the fraction of light lost through the aperture DD' is determined by the distance ST. For particular filament dimensions and choice of ω_o the radius (r) determines the distance ST.

The angle of maximum divergence from the axis of the lamp for light output shown as ω_o has been selected in a practical situation as being limited to approximately 30 degrees and in fact 30 degrees in the preferred embodiment.

Referring now to Figure 1, this shows in cross-section a reflector 1 encircling an incandescent lamp with filament 3.

The outlet aperture shown as a window at 4 has a peripheral seal 5 and connects to a cylindrical reflector.

The cylindrical reflector 6 has an internal surface adapted to provide for reflection of the output signal from the reflector 1 and direct output from the filament 3.

At the outer end of reflector 6 are two filters a first at 7 being peripherally sealed at 8 and being of absorption type selected to provide a sharp cut off of absorption of any light below a selected wave length but in this particular case having regard to the tissue absorption any wave length less than 620nm.

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A second filter at 9 is an interference filter providing an effectively sharp cut off of radiation above a selected wave length and having regard to the particular characteristics of the photoactive drug used, in this instance this is selected at approximately 680nm.

With this preferred embodiment, the interior of the cylindrical reflector 6 is filled with water and there is a circulation passage way providing for passage of the water through chamber 11 which is behind the first reflector 1 whereby to provide cooling of the reflector in this location.

To provide for concentration of the radiation, there is now provided a further reflector at 12 the characteristic of which is selected so as to concentrate the light through a smaller output aperture at 13 with a consequent expansion of the maximum angle of divergence from the axis of the lamp.

The shape of the generator of the reflector concentrator is now described with the assistance of Fig. 2 in which the portion of the generator from (A) through to (B) is a parabola whose focus is at (C') and whose axis is parallel to (CA') making an angle ω_1 to the axis OX and the shape of the generator from (B) to (C) is a straight line making an angle (ω_2) with the axis OX. BC is tangential to AB and the maximum angle of divergence of radiation exiting from the aperture CC' is ($\omega_1+2\omega_2$). The axis of revolution of the reflector is (OX).

In this way, by appropriate selection of the dimensions and criteria of the concentration, the maximum angle of divergence of radiation exiting from the exit aperture (CC') can be kept not greater than a desired value being 60^{o} in the preferred embodiment.

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Having now described in brief terms the embodiment, the result of use of this preferred embodiment is such that by using a tungsten filament quartz halogen bulb as the source of one kW of radiant energy such a lamp can be made relatively economically and nonetheless can deliver high power from an apparatus which is able to be relatively portable.

Careful selection of the design criteria and selection of reflector surfaces and selection of an arrangement of parts including a water absorber for the absorption of radiation of wave lengths substantially greater than 680nm has resulted in the lamp providing a high efficiency in terms of delivered output power over a suitably narrow wave length band.

In experimental trials, it has been shown to provide a useful source of such radiation over the effective wave lengths.

In addition to the preferred embodiment described, it is permissible to add or even take away some portions without departing at least from the broader concept of the invention.

Accordingly an additonal concentrating lens can be added at the outlet 13.

The shape of this lens can be based on the same principles as that of reflector 12 so reducing the aperture and hence increasing the maximum angle of divergence.

Alternative lenses with the purpose of redistributing the light intensity can be designed to attach at 13 or 14. In one instance this may have the purpose of producing an approximately uniform light intensity.

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The illustration has selected for matters of convenience a range of angles of divergence which are found to be preferred.

It is to be stressed that some variation from the selected range of angles of divergence from the axis of the lamp can occur without departing from the substantial spirit of this invention. Furthermore, the location and slope of the cut off edge of multi layer dialectric edge filters of the type that are used in the preferred embodiment varies with the selected angle of incidence and hence for different angles of incidence may require appropriate modifications in the reflector design.

This is not to say that the substantial design of the reflector should alter but that the detailed dimensions may vary in accord with the variation in filament shape or design or for a different output angle of divergence from the axis of the lamp.

It is a facet of the design that it is a non-imaging device.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. Apparatus for effecting useful irradiation of tumours having therein a photoactive drug, including an incandescent filament to provide a light source, a reflector surrounding the incandescent filament a characteristic of which reflector with respect to an outlet aperture within the apparatus is that light when emanating from the filament will be at least substantially directed and reflected to pass through the aperture so as not to have greater than a selected angle of diversion from an axis of a lamp, a chamber connected to the outlet aperture being otherwise shaped so that light passing therethrough from the filament will retain at least substantially its entry angle of divergence with respect to the axis of the lamp and containing therewithin a liquid effective to provide absorption of a range of wave lengths of light passing therethrough, and at an end of said chamber filters including an interference filter positioned and shaped and of such a size that light emanating from the said filament and having passed through the said liquid will strike said interference filter with an angle of incidence to the filter not greater than a selected suitable value.

2. An apparatus as in claim 1 further including a reflector shaped and located so as to accept light passing through the several filters including the interference filter at an end of said chamber, and adapted to reflect light passing through the said filters emanating from the filament so as to concentrate this light through a smaller outlet, there being as a consequence a range of angle of divergence through which the light will be distributed as it exists from the apparatus.

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3. Apparatus as in either of claims 1 or 2 wherein the range or angle of divergence from the axis of the lamp as the light emanates from the aperture of the reflector surrounding the filament is approximately 30^{o}.

4. Apparatus as in any one of the preceding claims wherein the liquid within the chamber is water.

5. Apparatus according to any one of the preceding claims wherein the chamber is connected by conduit to heat exchange means whereby to provide for circulation of the liquid and cooling of the liquid thereby within the chamber.

6. Apparatus according to any one of the preceding claims wherein the filament is of a substantially coiled cylindrical shape with the axis of the cylindrical shape being coaxial with the axis of the lamp.

7. Apparatus according to any one of the preceding claims wherein the reflector surrounding the filament is a compound paraboloidal reflector.

8. Apparatus according to any one of the preceding claims adapted to have a peak output of light of approximately 680 nm wave length.

9. Apparatus according to any one of the preceding claims which is adapted to most effectively irradiate tumours where the tumours contain the substance "HAEMATOPORPHYRIN DERIVATIVE".

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10. Apparatus for effecting useful irradiation of tumours having therein a photoactive drug substantially as described in the specification with reference to and as illustrated by the accompanying drawings.

Dated this 29th day of May, 1986.

THE UNIVERSITY OF ADELAIDE,
FREDERICK JOHN JACKA and
JOSEPH BLAKE,
By their Patent Attorneys,
COLLISON & CO.

A T.

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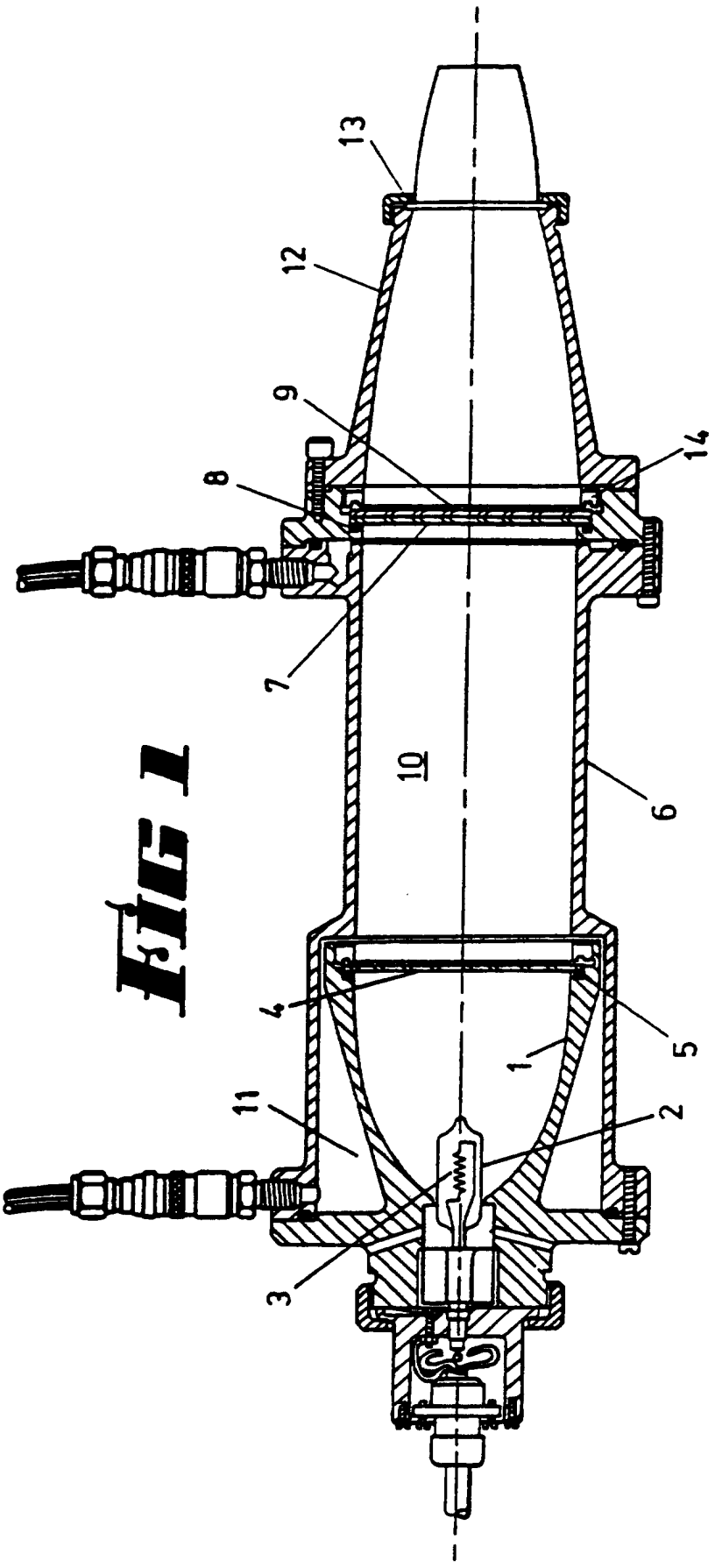


FIG 1

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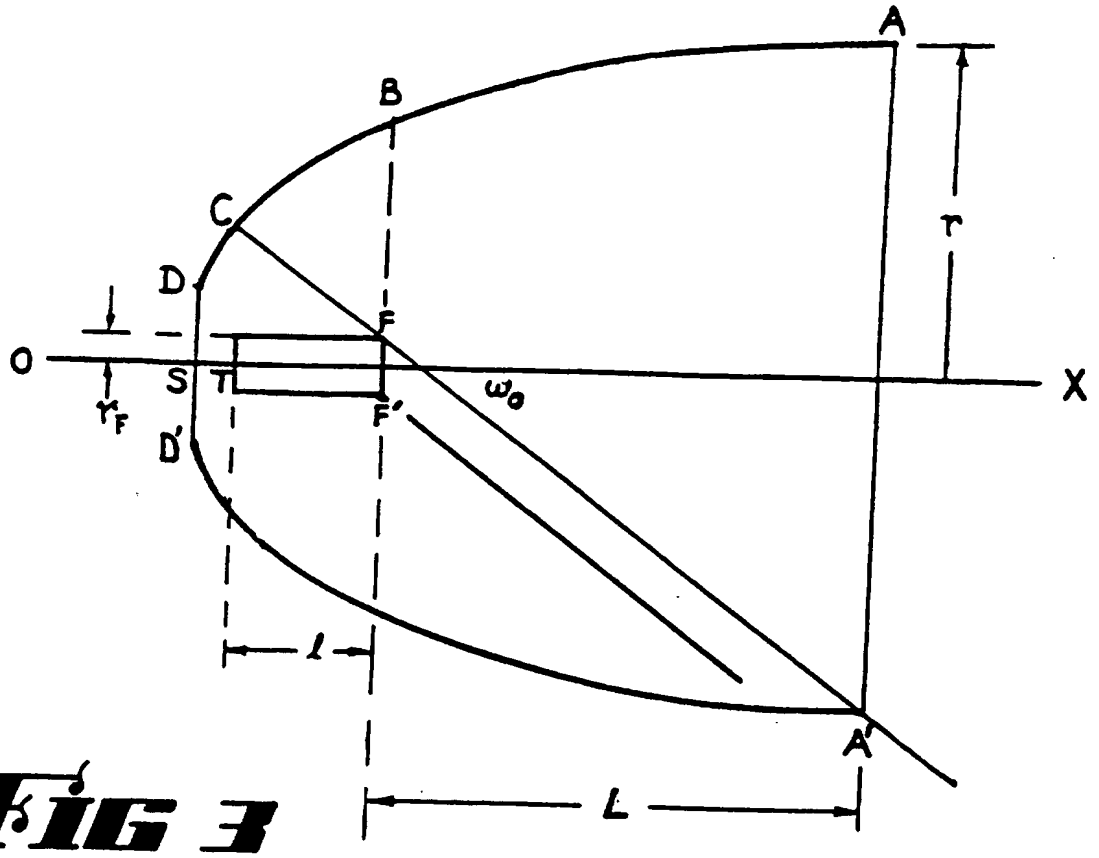


FIG 3

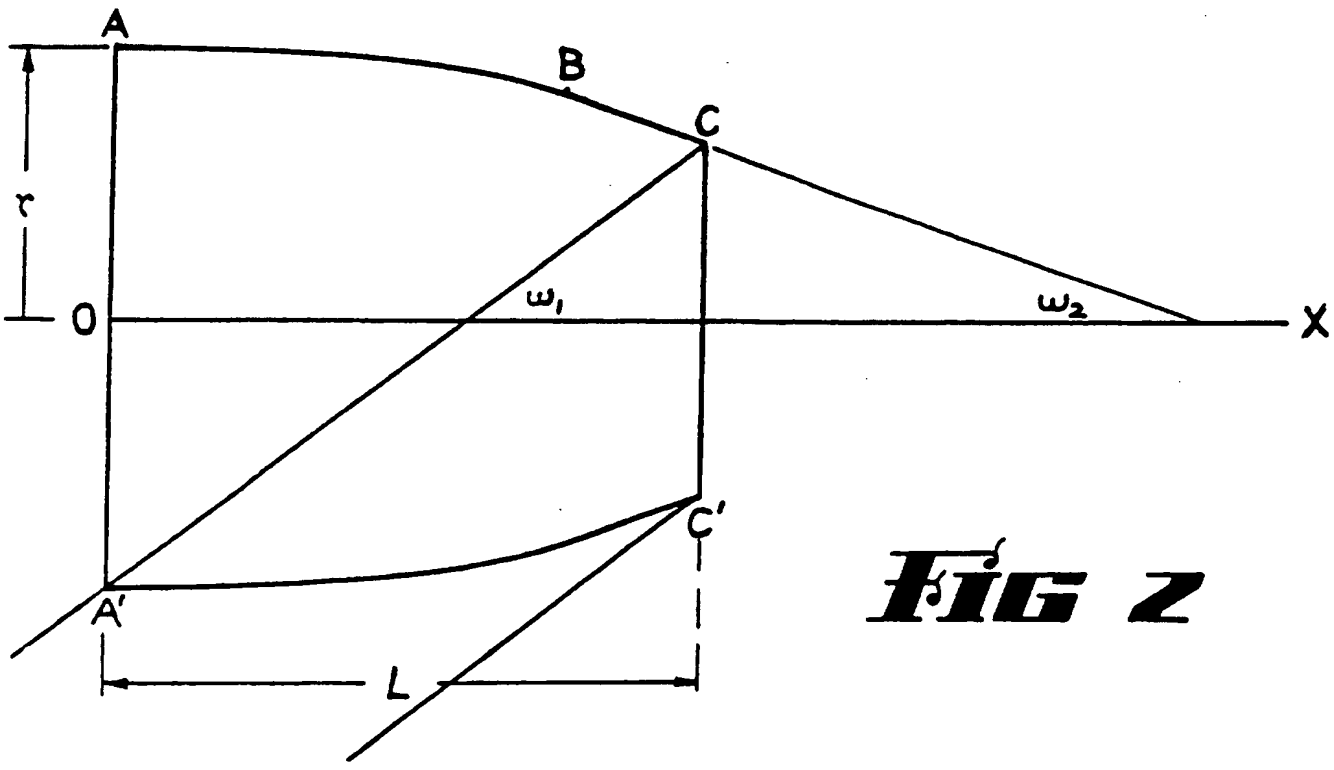


FIG 2

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